ART. I.—*Notes of a Geological Trip over the Coal Basin of New South Wales.* By MR. THOMAS HARRISON.

[Read 9th July, 1866.]

I need not tell those who have visited the spot that the harbour of Port Jackson is one of the loveliest sheets of sea water in this quarter of the globe. It is not, however, so generally known that there are many other inlets along the New South Wales coast line the features of which, although falling somewhat short in point of beauty, nevertheless bear a strong family likeness to those witnessed in the immediate vicinity of the sister metropolis. Each of these is distinguished by bold beetling cliffs, jutting promontories, is often almost landlocked ; and has one or two nearly barren but fairy-like islands reposing on its bosom. Such are Broken Bay, Shoal Haven, and Pitt Water. They are all, in fact, due to the same cause, that is, the wearing, by waves and other forces of the sandstone of the district into miniature gulfs and inlets, and are therefore found at intervals along the entire line of coast bounding this particular geological formation. This formation extends from Sydney inland to some little distance westward of Mount Victoria on the Bathurst-road. Longitudinally the same is marked upon the map affixed to Count Strezelecki's *Physical Description of New South Wales,* as stretching from the north near Newcastle to the south near Jarvis Bay ; but detached portions of the same rocks would appear to be found at points very much nearer to Cape Howe, since the Pigeon House is described by Mr. Clarke as being an undenuded outlier, resting as I suppose upon granite. As the widest part of the formation is about its centre the configuration of the whole resembles an irregular oval, of which the conjugate and transverse diameters run respectively from Maitland to the Kangaroo River and from Broken Bay to Hartley.

The line of route taken during the trip I am about to describe was to the last-named locality, lying about eighty

miles from Sydney, and afterwards along the coast to Newcastle, and from thence to Maitland and Stony Creek by railway.

The first forty miles of the former journey is made by train on the Great Western line as far as Penrith, and thence by coach over the Blue Mountains. What I may term the civilized part of the road to Hartley, that is, the distance lying between the terminus of the railway at Sydney and the one at Penrith, does not arrest the attention by any very striking features. The country round never rises above nor seems to fall much beneath mere mediocrity. It is slightly undulating, seems moderately green and fertile, with neither any very wide extent of woods, of open country, of cultivated spots, or of barren regions. Its general appearance is of a mixed description. It is everything—that is everything Australian—by turns, and nothing long. Here a bit like the Plains of the Werribee, a mile or two reminding one of the wooded region on the line to Ballarat, a valley —only on a more minute scale—such as those of the Barrabools, with a farm or two, a station or two, and any quantity of public-houses thrown in wherever there appears a valid excuse for building one ; and save that there are some orange groves and churches of a nondescript style of architecture at Parramatta, there is literally nothing else worthy of notice for over two score miles.

Of course the rocks are of the carboniferous age, and belong so far to the WIANAMATTA BEDS. According to Mr. Clarke these beds consist of brownish, greenish, or grey and yellowish nodular or ferruginous shales ; light or dark colored grits or sandstones, very calcareous, and charged with ironstone nodules. They are the uppermost beds of the series, and appear to contain some few, but very thin, seams of coal. Their outline, as seen on the map, is of an oval form, and their extent is about that of the county of Cumberland, nearly the whole of which is occupied by them.

From Penrith the remainder of the journey is made by coach. The first few miles is over what are termed the Emu Plains, a flat extent of country, but whether the result of deposits of alluvial or of a regular planing down of the surface by aqueous agency, was not easily discernible during our passage over it in the twilight. These plains are terminated by the River Nepean, a tolerably broad stream, and, crossing this, one is speedily at the foot of the celebrated Lapstone Hill, geologically in the area of the Hawkesbury

Rocks, and literally in the region of wayside public-houses, innumerable teams of weary horses, barrenness, bad roads, and bushrangers. I am not going to describe the forty miles of turnpike—for such it was—thus gone over, although, from the quantity of sand everywhere, the description might prove not altogether impertinent to such a paper; and although the time of traversing the same occupied ten hours, or as I believed at the period rather more than double that number of geological epochs of your explorer's life. And all this time was one incessant series of jolts and tumbles, varied sometimes by the coach standing as I fancied on its head and at others turning a somerset. I think I left much as Philip Vanderdecken may probably feel when he has vainly essayed doubling the Cape until he sees the South Pacific gradually dry into another Sahara, that all the while causesdhim to pitch and toss for ever over waves of sand, for the road everywhere was sand and nothing else, and over ridges of this like waves, and down into valley-like hollows, we surged and tumbled through the hours, or through the epoch, until gladdened by the sight of the Valley of Hartley at break of day.

This valley, as is the case with all other valleys of the district, is of a most interesting character. There is a tolerably level portion at the bottom, mostly thickly timbered, then a steep slope covered by gigantic trees, above which the upper portion of the valley's side is seen to rise in an almost perpendicular wall of rock, which often runs on in an almost unbroken line for many miles. Along the top of this wall-like conformation there is almost a continuous level superficies; but this although of tolerably even surface is of exceedingly irregular outline. There are tongues of land that run out into the valleys like promontories, and narrow necks that seem as it were isthmuses. Anon and you see a detached hill with its level top also looking like an island, or the valley opens into a wide-spread gulf with branching arms of the most fantastic shape. Raise Sydney Harbour and the Parramatta River into dry land and you will have one of the valleys described, or sink the valley so that it may be flooded with sea water, and straightway you will have an exaggerated representation of one and all of the romantic inlets of the eastern coast.

The shore line from Sydney to Newcastle is, for the most part, wild and rugged, and is fringed with one or two romantic-looking rocky islands, lying a mile or two out to

sea. The cliffs near Newcastle are precipitous, and the "Nobbies" standing at the mouth of the Hunter has an especially escarped appearance, but nothing, not an absolute bowling-green, can be flatter than the country bordering the same river as far as Maitland. The whole is one wide-spread plain of fertile alluvial, out of which rise a few rounded hillocks of carboniferous rocks left undenuded. A more striking contrast to the country near Hartley can scarcely be conceived. The two districts severally display examples of one and the same geological formation, acted upon by different natural forces. The results witnessed are, as I think, precisely what the student of geology may expect to find under the circumstances of the case.

THE STRATA.

The rocks spread over the whole of the districts described have a strong family likeness not only to each other but to similar deposits in Tasmania and in Victoria. With ourselves the lower beds of the series do not appear to have been reached, but in Tasmania, in consequence of great volcanic disturbances, the entire group can be examined from top to bottom. We have, for instance, near Hobart Town, in a descending order, sandstone with coal seams and shales, claystone and limestone full of fossils. In New South Wales, near Sydney, and in the centre of the deposit nothing but sandstones are visible; but at Newcastle the edge of the basin towards the north, and at Wollongong the like edge towards the south, the equivalent of the Tasmanian limestone is met with, similar in position, at the bottom of the series, containing fossils in every respect like those in the Hobart Town beds, only that it appears to be much less calcareous. Coal, however, appears to lie at a greater depth in the New South Wales than in the Tasmanian basin, since in the latter no seams of coal or even of coal shale are dug below where the claystone—400 feet in thickness—commences, whilst at Newcastle coal is profitably worked only a few feet over, if not actually below, portions of the limestone itself.

At Hartley only a very few shafts and borings have been attempted; the series has not, therefore, been examined to its entire depth in this locality. Only a few miles further west, however, granite is found to crop out, and to form the base of hills, the tops of which are of the generally prevalent

sandstone. The fossiliferous limestone or its equivalent is at this spot shown to be absent, not even the silurian strata intervening between the sandstone and the crystalline rocks. This fact, taken with the circumstance that limestone forms the base of the series in Tasmania, at Newcastle, and at Wollongong, goes in some measure to point out the conditions under which the entire formation came to be deposited, viz., that after the laying down of the limestone there existed, hereabouts, a gradually sinking sea bottom, since the circumstance that no limestone is found reposing upon the granite shows that at the time of the limestone's formation the granite must have existed in the form of islands, afterwards so far submerged as to allow of a subsequent thick layer of sandstone being thrown down upon them.

I had neither time nor opportunity to explore personally these deposits, but what fossils obtained from them were shown me in private collections, were found to resemble in the most striking manner similar organic remains which I had met with near Hobart Town, and consisted for the most part of *Fenestella Producta, Terebratulidæ, Conularæ,* and *Orthoceratites.* I may mention that at Raymond-terrace and also at Illawarra *Terebratula hastata* is mentioned by Stezelecki as a common fossil, one which Mr. Geikie, in his "Story of a Boulder," speaks of as occurring at depths of not more than 50 fathoms ; here then, if the latter assertion is correct, is something like reliable data by which the maximum depth of the sea hereabouts during the limestone era, may be approximately arrived at.

A paper professing to treat of the geological features of the Hartley, Newcastle, and Wollongong districts would be manifestly incomplete, if no allusion were made to the large deposits of bituminous shale met with in each of these localities. That of Hartley is, at present, for the most part obtained from one of the valleys of the Blue Mountains, previously alluded to, termed Petrolia Vale. The deposit occupies the very bottom of the slope of the two sides of the valley, and probably once extended, if it does not now extend, completely across the intervening flat, made up of alluvial accumulations. On the western slope it is seen to crop out at the surface, and is procured by driving a tunnel into the hill side, but on the opposite side of the valley it is only reached by means of a shaft some thirty feet in depth. The seam here hit upon is of exceeding richness, yielding over 160 gallons of crude oil to the ton. In its purest state

the mineral has a texture somewhat like very closely grained wood, and breaks with a conchoidal fracture, but the seams do not appear to be of equal richness throughout any very great area. The small specimens which were obtained from a boring near Mount Victoria show considerable diversity in the same seam, and that within a very short distance. The richest of these does not even approach in worth that of the main seam, but as they fell into my hands immediately after having been brought up by the borer, and as they illustrate the variations met with I elected to exhibit them. The seams, although compact from top to bottom, are divided by perpendicular fissures into huge blocks, which divisions would seem to indicate that after deposition considerable shrinkage has taken place. Both above and below the seam are found layers of fireclay, and also strata of shale, much more impure than is the main seam, but containing large quantities of bituminous matter and highly inflammable. What is regarded as the equivalent deposits of the Hartley shales at Stony Creek, near Maitland, have almost the appearance of cannel coal, yielding a dense black oil of nearly the consistence of gas tar. The shales at American Creek, near Wollongong, are often nearly as soft as leather, can be cut into flakes with a knife, and the liquid yielded by distillation resembles a purely vegetable oil.

In writing of the New South Wales' coal measures, in his "Southern Gold-fields," the Rev. W. B. Clarke says: "Conglomerates of the carboniferous beds have been found by me occasionally auriferous—that is, pebbles in the rock have contained visible gold. Such I have mentioned as occurring on the north shore of Sydney Harbour, where I have collected some dozen specimens. But I consider these to have *no commercial value,* and, therefore, to have no bearing except in a geological point of view; they merely tend to show that the opinions of certain distinguished geologists in Europe, respecting the age of the gold, are not always applicable." This statement is of especial interest to ourselves at present, since the Victorian Government geologist has lately propounded a theory, that all quartz drifts found in the miocene are non-auriferous, and that the Victorian quartz reefs were not formed, or being formed were not impregnated with auriferous particles, until the pliocene period. Mr. Selwyn is, I think, too great a lover of facts not to duly appreciate this one, coming from so reliable an authority

as Mr. Clarke. The circumstance of auriferous drifts not being found in miocene beds is a species of negative evidence that must undoubtedly yield before a solitary specimen positively instancing the direct converse. The actual existence of gold at the very earliest times would appear to be clearly proven. Whether its formation was gradual, extending over a long period, and developed in different areas at different dates, is another question. A few isolated reefs may have been thrown up previous to the mesozoic ages, and the great majority of them may have had no existence until just previous to the advent of man himself. There is one circumstance in some way seeming to bear upon Mr. Selwyn's theory, which ought not to be passed over. At Keilor, Flemington, near Ivanhoe, and in many other portions of the colony, quantities of an immensely hard tertiary rock are met with. The formation is evidently the result of some large out-pouring of water, highly charged with silicious matter. Now grant, as many suppose, that quartz reefs are of aqueous origin, and the result would be that the springs forming them would escape from their respective fissures, still strongly charged with silica, which would be speedily deposited as a matter of course. Can it be that the beds referred to are traceable to such a source; if so, then the quartz is clearly of tertiary origin, since the silicious deposits of which I speak contain leaves and plants, which I believe are pronounced by the Government botanist, Dr. Mueller, to be of not earlier than the miocene period?

A careful study, however, of the carboniferous rocks of New South Wales will, I think, suggest a reason other than that of the modern origin of gold, why our miocene rocks are not auriferous. They, the carboniferous beds, have everywhere been subjected to immense denuding forces. They once extended over an area much greater than that which they at present occupy. The rocks of Western Port, of Cape Otway, of North Gipps Land, Arapiles, and Mansfield, are probably their equivalents, and very possibly their outliers. Victoria, in fact, as I am informed, is pretty thickly studded over with isolated patches, which seem to show that such rocks once covered by a thick layer the major part of the entire colony. The rough section before you shows Mr. Selwyn's views relative to this matter, and by this it will be seen that a vast dome of sandstone, since swept away, extended from North Gipps Land to the Grampians. Now, whilst this dome remained still intact no

denudation of silurian rocks, or of their contained quartz veins, could possibly take place ; and the miocene rocks generally bear strong evidence of being derived rather from the mesozoic—that is, the carboniferous shales and sandstones, than from the older rocks. The pliocene beds, on the other hand, contain the refuse of silurian rocks in great abundance. Hence the non-auriferous character of the former, and the rich gold deposits found exclusively in the latter. You cannot very well divest a man of his shirt whilst he is still wrapped up in his overcoat. The older rocks of Victoria probably enjoyed an immunity from denudation in the miocene period from a somewhat similar reason ; they were at that time covered to a thickness of many hundred feet by the lower mesozoic and the upper palæozoic deposits. I put forward this bit of theorizing with the utmost diffidence—a diffidence which would be still greater only that I find my own views upon the subject are identical with those of more than one geologist, whose acquaintance with Victorian strata is by no means contemptible.

But then again it must be conceded that there are some few places, as on the beach near St. Kilda, where patches of what seem to be miocene repose immediately upon silurian strata—a fact somewhat militating the theory just laid down of the older rocks being covered by carboniferous beds during the earlier tertiary period.

I trust that this attempt to illustrate a fact in Victorian geology, by the phenomena observed in an adjacent colony, will not be deemed an unpardonable digression. I trust also that I have stated the case with all fairness, for I assure you that, equally with Mr. Selwyn and your Society, I am only desirous of eliciting the truth.

DENUDATION.

I come, in the last place, to what is perhaps the most interesting feature of the sandstone formation of New South Wales—viz., the very remarkable manner in which the strata have been worn into deep valleys and gorges, presenting phenomena unparalleled in any other portion of the world.

The denudation that has taken place near Newcastle, where the surface has been literally planed down by aqueous agency, presents but few difficulties. The phenomena wit-

nessed are just such as might result from powerful ocean currents passing over masses of rather friable sandstone. Similarly we are not startled to see, worn as they are, the valleys of the Barrabools, nor is it beyond the bounds of probability to conceive the vast sandstone dome removed from the centre of Victoria by long-continued oceanic action. The destruction, too, of the cliffs near Sydney is only what might be reasonably expected from the enormous billows which almost constantly break upon the shore in that locality. The geologist, however, is not a little surprised to find cliffs similar to those of Port Jackson eighty miles inland. Speaking of one of these in the vicinity of the Weather-board, Mr. Darwin says: "The country here is elevated 2,800 feet above the sea. About a mile and a half from this place there is a view exceedingly well worth visiting. Following down a little valley, and its tiny rill of water, an immense gulf unexpectedly opens through the trees which border the pathway, at a depth of perhaps 1,500 feet. Walking on a few yards, one stands on the brink of a vast precipice, and below one sees a grand bay or gulf—for I know not what other name to give it—thickly covered with forest. The point of view is situated as if at the head of a bay, the line of cliff diverging on each side, and showing headland after headland, as on a bold sea-coast." And, again: "Great arm-like bays, expanding at their upper ends, often branch from the main valleys and penetrate the sandstone platform; on the other hand, the platform often sends promontories into the valleys, and even leaves in them great, almost, insulated, masses."

In attempting an explanation of the phenomenon, Mr. Darwin further says: "The first impression, on seeing the correspondence of the horizontal strata on each side of these valleys and great amphitheatrical depressions, is that they have been hollowed out, like other valleys, by the action of water; but when one reflects on the enormous amount of stone, which on this view must have been removed through mere gorges in chasms, (for the valleys many miles in breadth at their heads often contract to not more than 2,000 yards at their mouths,) one is led to ask whether the spaces may not have subsided. But considering the form of the irregularly branching valleys, and of the narrow promontories projecting into them from the platforms, we are compelled to abandon this notion. To attribute these valleys to the present alluvial action would be preposterous; nor does the

drainage from the summit level always fall, as I remarked near the Weather board into the head of these valleys, but into one side of these bay-like recesses." Mr. Darwin's own idea is, that what we see are the remains of enormous banks of sand, such as are now being formed in the West Indies and in the Red Sea, where it is said that the sea heaps masses of sand around rocks and islands, and in the most irregular forms. It is with great reluctance that I differ from a geologist so experienced as the author of the "Origin of Species;" but I do not think such an explanation as that given will satisfy one person out of a hundred who has seen the valleys in question.

If I must venture on a hypothesis I should certainly refer what is witnessed to fluvial if not to atmospheric action. The valleys, only on a grander scale, resemble the gullies which one sees cut into pliocene drift on the coast, more than anything else I am acquainted with. There is, or there was, previous to its being lately planted with fern trees, a gully in the Government House Reserve that looked like one of the Blue Mountain valleys seen through the wrong end of a telescope. This we know was the result of rain water, and it is only a question of time that would refer the larger valley to the came cause.

But take an instance much more striking and conclusive, Near Keilor we have a valley nearly one hundred feet in depth cut through, not friable sandstone like that of New South Wales, but indurate basalt, hard silicious rock, and compact silurian strata. All this has been done within a very limited period; for the basalt in question is, if I mistake not, pliocine. All has been done, too, by a tiny stream, the Deep Creek, for there are many circumstances which go to show that in the excavation of this particular valley waves and currents of the sea could have played no part. Take an instance, if possible, more striking still, the denudation of the basalt on the top of Mount Useful. This, too, is of recent origin, and yet was ever destruction of a rock and removal of the eroded material more complete and perfect?

Now the Blue Mountains bear evidence of being of immense antiquity, not only as a deposit, but as subsequently upheaved dry land. If I might hazard an opinion I should certainly speak of them as being, with the exception of our granitic chains, as the oldest land in Australia. The central portions of Victoria must have remained under water to a much later date, or how could the equivalent

strata have been denuded from above the silurian rocks. In the Blue Mountains, too, so far as I could gather, no evidence of tertiary deposits are anywhere apparent. Here is another proof of immense antiquity. It gives us time wherein to do our work, but, furthermore, it presupposes the existence of a force whereby the work would be carried on. If the district remained dry ground during the tertiary age it could only have done so as one or more of a group of islands. Under such circumstances the rainfall must have been vastly greater than at present. Torrents might have roared down these now dry hill slopes and even rivers have flowed along these now arid valleys.

As to time for working out such grand results by such trifling agencies, of geologic time we know comparatively nothing. We have long since abandoned the old interpretation of Genesis, limiting the world's age to 6,000 years. Having done so, I am at a loss to know what reasonable argument can be adduced for refusing the geologist any extension of time whatever, short of an eternity, during which the grand results he contemplates may have been brought about.

Art. II.—*On the Theory of the Formation of Gold Nuggets in Drift.* By Mr. C. Wilkinson.

(Read 11th September, 1866.)

Mr. President and Gentlemen of the Royal Society,—It has hitherto been a moot question, and one which has elicited no small degree of discussion, respecting the occurrence of *larger nuggets* of gold in the drifts than have yet been discovered in any quartz reef; and that alluvial gold is generally of a higher standard than that obtained from the reefs.

Many theories have been introduced to account for these phenomena: among them is one which does not appear to have received that amount of attention it evidently merits. I allude to that advanced by Mr. Selwyn, the Government geologist, suggesting the probability of gold existing in solution in the mineral water permeating the silurian rocks and the gold drifts; and that this water, in its passage through the drifts, became by some unknown means decom-